4 Site Screening Levels

This section discusses screening levels applicable to the investigation and cleanup of the Whatcom Waterway Site. These screening levels are used in Section 5 in the evaluation of the nature and extent of contamination, and in the Feasibility Study to set the goals for remedial actions at the site.

4.1 Overview of Exposure Pathways and Receptors

The cleanup of the Whatcom Waterway Site must ensure protection of human health and the environment. The MTCA and the SMS provide the regulatory context for evaluating site contamination and cleanup goals. These goals address protection of sensitive receptors under various potential exposure pathways as identified in Table 4-1. The subsequent text in this section provides a discussion of each of the principal screening levels applicable to the site and carried forward in the RI/FS.

Table 4-1 Principal Receptors and Exposure Pathways

Receptor	Exposure Pathway	Protective Screening Level
Benthic Organisms	Direct Toxic Effects to Organisms Present in Site Sediment	SMS chemical and biological criteria (Section 4.2)
Human Health	Chemical Exposure through Consumption of Site Seafood	Site-Specific Bioaccumulation Screening-Level (Section 4.3)
Ecological Health	Chemical Exposure through Consumption of Site Seafood	Bioaccumulation Screening-Level (Section 4.4)
Other Receptors (Human Health and Ecological Receptors)	Waste Management During Site Remedial Actions	Other Applicable Regulatory Requirements (Section 4.5)

4.2 Protection of Benthic Organisms

The SMS provide a uniform set of rules and procedures to evaluate the cleanup of contaminated sediment sites (WAC 173-204). The SMS regulations are enforced under the MTCA (Chapter 70.105D RCW). These regulations provide numeric and narrative standards that provide a basis for determining when contaminants are present at levels of potential significance.

4.2.1 SMS Chemical Screening Levels

Under the SMS, two sets of numeric standards have been established for chemical contaminants. The first of these, the sediment quality standard

(SQS), is a criterion at which no adverse effects "including no acute or chronic adverse effects on biological resources and no significant health risk to humans occur" (Ecology, 1995). The SQS are a regulatory and management goal for the quality of sediments throughout the state. The second criteria, the minimum cleanup level (MCUL), is a minor adverse effects level, which is the minimum level to be achieved in all cleanup actions under SMS. SMS regulations apply different restoration time-frame expectations to cleanup actions for compliance with the SQS and MCUL. SMS regulations expect that cleanup actions will comply with the MCUL immediately following active remediation, whereas the regulations allow typically 10 years for compliance with the SQS following the completion of active cleanup.

Compliance with SMS criteria can be assessed using chemical testing methods defined under the Puget Sound Protocols (Puget Sound Estuary Program, 1986) and in amendments to those protocols as established by Ecology. During the Whatcom Waterway RI/FS investigations, extensive chemical testing was performed for surface and subsurface sediments.

SMS marine SQS chemical criteria are defined in WAC 173-204-320 and numerical values are presented in Table I under that section of the regulations. The chemical parameter criteria are defined on either a dry weight basis or on an organic carbon normalized basis for certain organic compounds. To normalize to total organic carbon, the dry weight concentration for each parameter is divided by the decimal fraction representing the percent total organic carbon content of the sediment.

SMS marine sediment MCUL chemical criteria are defined in WAC 173-240-520 and numerical values are presented in Table III under that section of the regulations. As with the SQS criteria, the values are defined on either a dry weight basis or on an organic-carbon normalized basis, depending on the properties of the chemical.

4.2.2 SMS Biological Criteria

SMS regulations define bioassay testing procedures and interpretive criteria that can be used to directly test sediments for adverse effects. Test methods and interpretive criteria have been developed, and provide for definition of two different thresholds of effect. The more stringent SQS provide a regulatory goal by identifying levels below which surface sediments have no adverse effects on human health or biological resources. The MCUL (equivalent to the Cleanup Screening Level or CSL), represents the level above which minor adverse effects may be observed.

Bioassays have been used to directly screen sediments in the site area for the presence of elevated contaminant levels or combinations of contaminants, or conditions suspected by Ecology to result in toxicity. Bioassays have also been used in a confirmatory role when chemical testing demonstrates the presence of elevated contaminant levels. As illustrated with Figure 4-1, the widespread use of whole-sediment bioassays as part of the RI/FS testing program ensures that any potential site impacts to benthic organisms are measured. This includes effects of specific potential contaminant fractions not directly quantified (e.g., methylmercury as a fraction of total sediment mercury), additive or synergistic effects associated with multiple contaminants, or effects of other contaminants not specifically included in the RI/FS chemical testing program.

Bioassay test methods that have been used at the site are defined in current Ecology regulations and include tests performed with amphipods, larval organisms, and juvenile polychaete worms.

4.3 Protection of Human Health

In addition to the evaluation of benthic effects and compliance with the SQS, cleanup levels at the site must protect against other adverse effects to human health and the environment, including food chain effects associated with the potential bioaccumulation of mercury.

Development of the BSL

Mercury is a compound that is known to bioaccumulate in aquatic organisms. The RI/FS activities included evaluation of mercury bioaccumulation, and defined a protective area-wide sediment concentration that would ensure protection of human health. This analysis was performed under very conservative assumptions. This protective area-wide sediment mercury concentration is known as the Bioaccumulation Screening Level (BSL). Figure 4-2 illustrates potential routes of potential mercury bioaccumulation and exposures applicable to Bellingham Bay.

Previous RI/FS testing data for surface waters in Bellingham Bay has shown that surface water complies with the most stringent of the State criteria (WAC 173-201a) for mercury. These criteria are based on prevention of bioaccumulation in seafood. Measurements for surface water were summarized in Section 8 of the 2000 RI/FS (Anchor, 2000). Results showed that surface water mercury levels were consistently below 0.025 µg/L. Since these measurements were taken, additional source control measures have been implemented, including the closure of the Chlor-Alkali Plant, and the implementation of the Interim Remedial Action within the Log Pond. The primary routes of potential bioaccumulation at the site are associated with remaining impacted sediments.

The BSL was originally developed as part of the RI/FS Work Plan, and the basis for the BSL was described in the 2000 RI/FS, which was subjected to public comment and was approved by the Department of Ecology. The BSL provides an additional measurement (in addition to the SMS chemical and biological criteria) which is relevant for measuring the performance of the site cleanup. The derivation of the BSL was completed in three steps.

First, paired fish tissue and sediment data from Bellingham Bay and other Puget Sound embayments with documented mercury contamination sources were tabulated. Sediment measurements for total mercury were used, because these data incorporate all potential chemical fractions and speciation of mercury, and are the most widely available and consistent measurements. Similarly, tissue measurements of mercury were based on total mercury measurements to ensure data comparability and to ensure complete capture of potential forms of mercury in the seafood. The sediment data are summarized in Appendix E. The data included bottom fish (English Sole), crabs (Dungeness and Red Rock Crab), clams, and mussels. Synoptic, quality-assured tissue and sediment data collected in Puget Sound areas characterized by elevated mercury concentrations (i.e., above the SQS) are primarily available from five information sources (generally listed in chronological order):

- Dungeness crab muscle tissue data collected during 1990 and 1997 in the greater Bellingham Bay area by the State of Washington (Ecology, WDFW, and DNR) (SAIC, 1990; Cubbage, 1991; L. Weiss, written communication, 1997)

- Red rock crab muscle tissue data collected in 1974 from the WW Area by Huxley College (Nelson et al., 1974), and in 1990 from Port Madison and West Eagle Harbor by EPA (CH2M Hill, 1991)

- English sole muscle tissue data collected over the period from 1991 to 1995 at numerous sites in Puget Sound by PSAMP (O'Neill et al., in preparation)

- Mixed hard-shell whole body clam tissue data collected over the period from 1990 to 1993 in Bellingham Bay and Puget Sound reference areas by Ecology and DOH (Cubbage, 1991).

Second, the relationship between tissue and sediment concentrations of mercury was determined using a regression analysis (Appendix E). To estimate sediment exposure corresponding to each tissue sample, available surface sediment samples collected within the estimated home range radius of the tissue sampling location were used to calculate an area-weighted average surface sediment concentration. For the purpose of the analysis, an average unconstrained home range of approximately 10 km^2 was used for these three mobile species evaluated (Red Rock Crab, Dungeness Crab, English Sole). The 10 km^2 area can be approximated as a circle with a radius of 1.8 km (1.1 miles). Regression analyses were performed for each of the three synoptic data sets. Of the regression analyses performed, the Dungeness crab regression yielded the most conservative bioaccumulation estimate of the species evaluated. The Dungeness crab regression line bounded the maximum English sole and Red rock crab muscle tissue projections. The Dungeness crab muscle regression equation thus provided a conservative upper-bound estimate of mercury bioaccumulation for a range of species.

Third, using conservative, screening-level risk assessment techniques, a conservative tissue benchmark mercury level was calculated to protect both recreational and tribal fishers who may consume relatively large amounts of seafood from Bellingham Bay. Screening-level risk assessment procedures outlined in MTCA (WAC 173-340-708) were used to estimate a human health benchmark dose and fish/shellfish tissue concentration which is protective of individuals who may consume relatively large amounts of seafood. The screening-level evaluation incorporated conservative exposure and risk assumptions, as follows:

- **Protective Mercury Intake Based on EPA Value.** The existing oral reference dose (RfD) for methylmercury used in this assessment was obtained from the U.S. Environmental Protection Agency's (EPA) Integrated Risk Information System (IRIS) database. The RfD is an estimate of daily methylmercury intake to a population, including sensitive subgroups, which is likely to be without an appreciable risk of deleterious effects during a lifetime. The methylmercury RfD (1×10^{-4} milligrams per kilogram per day [mg/kg-day]) was conservatively applied to assess total mercury concentrations in fish and shellfish tissues. This provides an additional level of conservatism to the estimates (i.e., the total mercury RfD is 3 times less stringent than that for methylmercury, and actual mercury speciation is unlikely to be 100 percent methylmercury in fish and shellfish tissue).

- **Crab, Bottomfish, Clams, and Mussels Assumed to be Harvested Entirely on Site.** The risk assessment calculations assumed that the fisher obtained 100 percent of their crab, bottomfish, clam, and mussel intake solely from the Site area (i.e., 100 percent diet fraction). Actual fishing activity is likely to be more varied, with fish and shellfish obtained from a variety of locations within the greater Bellingham Bay and Rosario Straits areas. For example, tribal fish consumption surveys (Toy et al., 1996) have documented that a significant portion of seafood consumed by tribal fishers is obtained form areas outside of Puget Sound, and that the fishing locations vary within Puget Sound. The assumption that all seafood is obtained from the Whatcom Waterway Site area (a small portion of Bellingham Bay) results in a significant overestimate of potential human health exposure via seafood consumption.

- **Conservative Tribal Fish and Shellfish Consumption Rates Assumed.** The most comprehensive evaluation of seafood consumption rates by regional tribal fishers is contained in Toy et al. (1996) based on studies of the Tulalip and Squaxin Island Tribes of Puget Sound. The conservative upper-bound (90^{th} percentile) combined consumption rate of crab, bottomfish, clams, and mussels from that study is approximately 70 grams per day (23.4 grams Dungeness crab, 7.8 grams total bottomfish and 38.5 grams clams and mussels), with additional consumption of salmonid, pelagic and freshwater fish. The overall seafood consumption rate used is equivalent to 173 grams per day of total seafood (rates normalized to a 70 kg adult). The seafood consumption rates used for BSL development are more conservative than the mean and median ingestion rates, and are substantially higher than the 95 percent upper confidence limit around the mean from the Toy study. The rates are also substantially higher than the rates currently used in the state MTCA regulations (27 grams/day). EPA risk assessment guidance for use with Superfund sites (EPA, 1997) recommends a mean *total* fish/shellfish intake rate of 70 grams per day, and a 95^{th} percentile consumption rate of 170 grams per day for protection of sensitive subsistence fisher populations, which is less than the assumed ingestion rates (173 grams per day) used for the BSL development. It is also important to note that the rates from the Toy (1996) study represent the *higher* of the adult and child seafood ingestion rates (normalized to body weight). This ensures that the BSL development is protective of both adult and non-adult populations.

Using the bioaccumulation regression analyses and the seafood consumption rates summarized above, the area-wide sediment screening level that ensures a mercury intake at or below the RfD were calculated. The resultant sediment screening levels calculated in this manner varied from 1.2 to 3.7 mg/kg, depending on the fish consumption rate and the regression analysis used (Appendix E). Using each of the most conservative assumptions produced a sediment bioaccumulation screening level of 1.2 mg/kg. The BSL has been carried forward in the Supplemental RI/FS for determination of required cleanup areas and for use in long-term monitoring of cleanup performance.

In applying the BSL to the site, it is important to understand the conservatism associated with the use of this value as applied by Ecology. Because of the conservatism of the assumptions on which the BSL was developed, the BSL is protective of human health even if one or more of the underlying assumptions were to change significantly. Examples of highly conservative assumptions used in the development and application of the BSL, and that tend to overestimate seafood consumption health risks, include the following:

- **Area-Weighted Averaging versus Point-by-Point Application:** The BSL was originally developed using tissue uptake exposures and area-wide sediment concentrations. However, the BSL has been applied by Ecology to determine cleanup requirements on a point-by-point basis (i.e., samples exceeding the BSL are considered contaminated, even if the area-weighted average mercury concentration within the site is far below the BSL). This application results in over-protectiveness by a factor of two to threefold (i.e., surface weighted average mercury concentrations within the site have been well below the BSL, and have been falling over time due to natural recovery processes and the implementation of the Interim Remedial Action within the Log Pond).

- **Mercury Speciation Assumptions:** As noted above, the assumption of 100 percent methylmercury speciation tends to overestimate exposure risk by 10 to 30 percent.

- **Diet Fraction Assumptions:** Also as noted above, 100 percent of the seafood ingestion is assumed to be harvested from the Whatcom Waterway Site, even though the site represents a small portion of Puget Sound, and seafood consumption surveys have documented a diversity of tribal fishing locations both within and outside of Puget Sound. This assumption is expected to overestimate exposure risks by over 50 percent.

Due to the conservatism of the assumptions underlying the BSL, the actual seafood exposure risks associated with mercury are expected to be substantially lower than estimated by the BSL. No mercury-associated seafood consumption advisories have been issued at the Whatcom Waterway Site, and none of the documented seafood tissue sampling data exceed safe mercury levels recommended by EPA (0.3 mg/kg wet weight).

4.4 Protection of Ecological Receptors

The application of the BSL as part of Whatcom Waterway Site investigation and cleanup activities ensures protection of both human health, and also provides protection of higher trophic-level wildlife exposures. For example, the BSL provides substantial margin of protection for marine mammals as described below.

As discussed in Section 3.1, some grey whales have been observed to enter Bellingham Bay and other portions of Puget Sound to feed opportunistically along their annual migrations between breeding ground in Baja, Mexico and their summer Arctic feeding grounds. Extensive monitoring of grey whale migrations, standings, and biological monitoring data has been performed by public and private organizations, including but not limited to NOAA, Cascadia Research, and the Ocean Sciences Institute. Direct testing of blood, tissue and body fat chemical levels have been performed on stranded, deceased whales and biopsies of living animals. Comparisons of heavy metal composition in stranded Puget Sound whales and whales in the Arctic feeding ground demonstrated no evidence of increased exposures for standard whales (Varanasi, 1993). Mercury levels in whale tissues were not significantly different between the two populations, and mercury levels were generally very low with no detectable mercury in neurological tissues which are the most sensitive to mercury exposures.

The observations from direct testing of marine mammals are consistent with quantitative exposure estimates based on feeding rates, measured invertebrate tissue levels, and mammalian effects levels for chronic and subchronic effects. Federal studies have established lowest-effects level and no effects levels for mercury of 0.8 mg/kg/day and 0.42 mg/kg/day respectively for mammalian studies (ATSDR, 1989). These studies are directly supported by experiments performed with felines, mice and rats including pre-natal exposure studies and long-term feeding studies (USAF, 1990; Chang et al, 1977; Fowler & Woods, 1977). At peak feeding rates of 2 percent of body weight per day, and using the maximum invertebrate tissue/sediment relationships as used to derive the BSL, average sediment concentrations equal to the BSL (1.2 mg/kg) would ensure a maximum estimated mercury exposure (0.02 kg food consumption/kg whale per day times maximum estimated crab tissue concentration from Appendix E) to the feeding grey whale (0.0036 mg/kg/day) that is over 100 times below the published mammalian no effects level (0.42 mg/kg/day). Actual exposures would be much lower due to the wide range included in whale feeding and the lower feeding rates typically observed during opportunistic feeding behavior.

Additional verification of the ecological protectiveness of the BSL is evident from review of other bioaccumulation screening levels, and from the results of direct bioaccumulation testing. The PSDDA program maintains bioaccumulation trigger (BT) values for a variety of contaminants. The Whatcom Waterway BSL (1.2 mg/kg) is more stringent than the current PSDDA BT for mercury (1.5 mg/kg). Additionally, direct bioaccumulation testing has been performed on Whatcom Waterway area sediments with mercury concentrations as high as 1.8 mg/kg, significantly above the BSL (Appendix H). These tests have shown no significant mercury bioaccumulation in the test conditions, in comparison to clean reference materials, confirming that the maintenance of mercury levels at or below the BSL minimizes the potential for significant bioaccumulation to occur.

4.5 Other Screening Levels

Specific evaluations performed as part of the RI/FS also included comparisons to other screening levels. These comparisons include the following:

- **Upland MTCA Cleanup Levels:** As part of the Feasibility Study evaluations, some scenarios were evaluated in which sediments could be reused in upland land use applications or could be used to create new upland areas. Under these scenarios, MTCA cleanup levels for soils and groundwater could apply and were used to evaluate the feasibility, implementability and costs of specific remedial alternatives.

- **PSDDA Program Standards:** The PSDDA program provides a comprehensive program for characterizing materials for open-water disposal or beneficial reuse. The program includes chemical and biological testing protocols to address toxicity of contaminants to benthic organisms and risk-based screening levels for use in evaluating potential bioaccumulation risks. The RI/FS evaluations included screening of materials from the Outer Waterway and the I&J Waterway against PSDDA program criteria. These results are specific to PSDDA program evaluations.

- **Regulatory Criteria for Other Media**: Some of the RI/FS activities included pre-design evaluations of contaminant mobility under simulated confined disposal alternatives. These evaluations included comparisons of leachate concentrations against state and federal water quality criteria. Disposal evaluations included testing of materials against disposal criteria established under other state and federal regulatory programs. These screening levels are discussed where applicable.

In addition to the screening levels listed above, background values were used where available to document natural background and regional background concentrations of chemical constituents.

PORT OF BELLINGHAM

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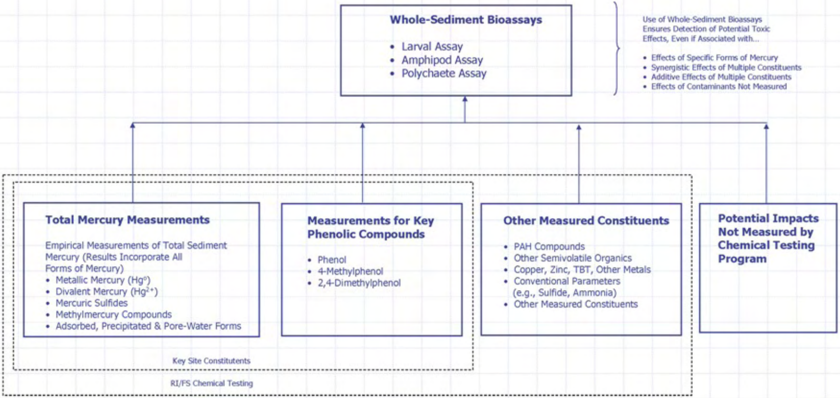
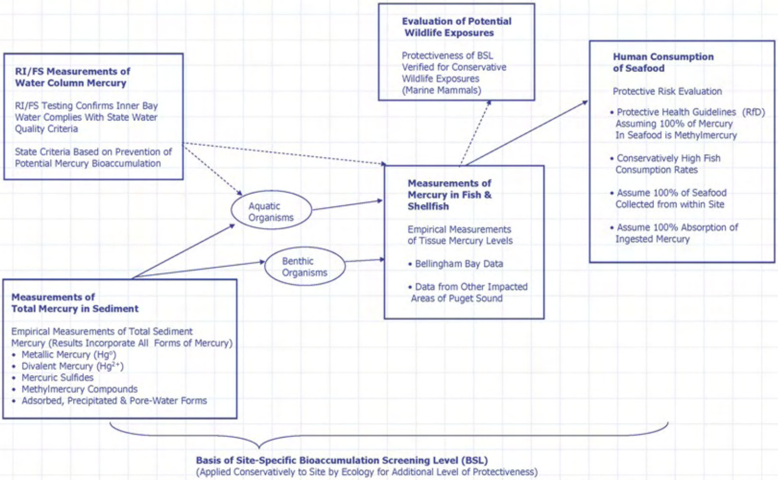
Figure 4-1
Verifying Protection of Benthic Organisms



PORT OF BELLINGHAM

Figure 4-2
Ensuring Protection from Potential Mercury Bioaccumulation

RETEC



5 Nature and Extent of Contamination

This section describes the results of investigations performed between 1996 and 2004 documenting the nature and extent of contamination in sediments at the Whatcom Waterway Site. Information covered in this section includes the following:

- Constituents of Concern (Section 5.1)
- Quality of Surface Sediments (Section 5.2)
- Quality of Subsurface Sediments (Section 5.3).

5.1 Constituents of Concern

The constituents of concern present within the Whatcom Waterway Site are described in this section. Section 5.1.1 describes constituents present in areas outside of the ASB. Section 5.1.2 then describes constituents present in the ASB areas.

5.1.1 Areas Outside the ASB

Key Constituents of Concern

Based on the series of sediment investigations performed for surface and subsurface sediments in 1996, 1998, and 2002, the key constituents of concern for the sediments in the Whatcom Waterway Site areas include mercury and phenolic compounds. It is these compounds that most frequently exceeded the chemical SQS values, the site screening levels applicable to aquatic areas of the Site.

Mercury has natural background sources, and a portion of the mercury present at the site is derived from natural sources. Based on United States Geological Survey (USGS) studies of natural background levels of heavy metals (USGS, 2001), soils in the greater Bellingham area exhibit natural background mercury concentrations between 0.05 and 0.20 mg/kg. The USGS database of natural background concentrations of heavy metals in United States river systems (Rice, 1999) similarly indicates a background concentration for most western river systems between 0.05 and 0.25 mg/kg. Regional deposition of mercury from atmospheric sources (i.e., combustion of fossil fuels and resultant deposition of mercury by fallout and precipitation) contributes to this background loading. However, these natural and regional sources are not likely to cause exceedances of MTCA and SMS screening levels within the site.

The chemical SQS for mercury is 0.41 mg/kg. The chemical MCUL for mercury is 0.59 mg/kg. These levels apply to total mercury, which is the parameter measured directly with the RI chemical testing program. As shown in Figure 4-1, the potential effects of the various geochemical forms of mercury (i.e., metallic mercury, divalent mercury, mercuric sulfides, methylmercury) were addressed using whole-sediment bioassays. Bioaccumulation affects of mercury (in its various forms) were addressed conservatively in the development of the site-specific BSL as illustrated in Figure 4-2, and discussed in Section 4.3 and 4.4.

Throughout the Whatcom Waterway Site areas, mercury was the compound most frequently detected above SMS numeric screening levels. These levels are greater than natural background concentrations, and the patterns of contamination are consistent with a localized source for the incremental sediment mercury content. The highest concentrations of mercury correlate with historical mercury discharges from the Chlor-Alkali Plant between 1965 and 1970 when pollution control upgrades were implemented by GP and to a lesser extent between 1970 and 1979 when direct discharge of mercury-containing wastewaters to the Whatcom Waterway area was terminated.

The main phenolic compound detected at elevated concentrations at the site was 4-methylphenol. The SQS and MCUL values for 4-methylphenol are both 0.67 mg/kg. This compound can be produced from a variety of natural and anthropogenic sources. Methylphenol compounds are produced in the absence of oxygen by the decomposition of organic matter such as leaves, wood, and other vegetation. Under appropriate conditions the compound is readily biodegraded and does not accumulate. Within the Whatcom Waterway Site, elevated concentrations of 4-methylphenol were noted predominantly in subsurface sediments with accumulations of former pulp waste discharges, wood waste accumulations, and debris from historic log rafting activity. These activities can produce deposits of organic matter that in turn produce 4-methylphenol as a decomposition product.

The phenolic compounds phenol and 2,4-dimethylphenol were noted sporadically in surface sediments. The SQS and MCUL values for 2,4-dimethylphenol are both 0.029 mg/kg. The compound 2,4-dimethylphenol can be generated from a variety of natural and anthropogenic sources, including stormwater discharges. These compounds were present predominantly in surface as opposed to subsurface sediments.

Other Constituents

Several other compounds were detected above screening levels sporadically during the Whatcom Waterway Site investigations. These compounds include the following:

- **PAH Compounds:** Several PAH compounds were detected intermittently in areas near creosote-treated wood structures and in subsurface rather than surface sediments. Concentrations of seven high molecular weight polycyclic aromatic hydrocarbons (HPAHs) and four low molecular weight polycyclic aromatic hydrocarbons

(LPAHs) exceeded their SQS criteria in at least one subsurface sediment sample. Only one HPAH, flouranthene, was present at concentrations above the MCUL (sample HC-DC-87-S1). Two LPAHS (fluorene and phenanthrene), as well as total LPAHs were also present at concentrations above the MCUL in sample HC-DC-87-S1.

- **Hexachlorobenzene:** The compound hexachlorobenzene was detected in excess of the SQS in one surface sample (HC-SS-34) and in several subsurface samples (HC-DC-89, -90, -91 and -92 and in HC-VC-80). This compound can be present in some pentachlorophenol treated wood structures.

- **Benzoic Acid:** One sample result (HC-SC-76) exceeded the SQS and MCUL criteria for benzoic acid (650 micrograms per kilogram (µg/kg) for both criteria). Like phenolic compounds, benzoic acid can be produced from the natural decomposition of plant debris or wood materials. It can also be present in stormwater discharges. Benzoic acid is readily biodegradable.

- **Copper and Tributyl Tin:** Localized detections of copper and tributyl tin were noted in surface and subsurface sediments along the shoreline of the Colony Wharf site (Appendix F). These detections appear to be associated with former boat maintenance activities that took place historically on and adjacent to the Colony Wharf site and historical operation of a foundry at the Colony Wharf site. The areas of sediment contamination located in this area are included within the investigation and cleanup area of the Whatcom Waterway Site.

- **Bis(2-ethylhexyl)phthalate:** This compound was detected in several samples located in the I&J Waterway area during initial RI investigations. Later Phase 2 investigations performed in 2001 by the Port determined that these detections were associated with a localized release along the I&J Waterway shoreline. This area has been designated as a separate cleanup site and is currently being investigated by the Port (the I&J Waterway Sediments site) under an Agreed Order with the Department of Ecology.

Constituents Not Analyzed

As shown in Figure 4-1 and discussed in Section 4, bioassay testing using SMS whole-sediment bioassays has been used to assess potential toxicity associated with other contaminants that could potentially be present but that were not specifically analyzed with the RI chemical testing program. The bioassays also provide a mechanism for evaluating potential additive or synergistic effects between tested chemicals.

Additional testing for dioxins and furans was not performed during the RI chemical testing program outside of the ASB. Testing for those compounds has been regularly performed as part of sediment monitoring of the outfall area by GP as part of their NPDES permit requirements. The GP outfall is managed separately from the Whatcom Waterway site, as part of GP NPDES permit requirements. No evidence of benthic toxicity as measured by sediment bioassays (Anchor, 2000b) at the outfall area. Testing of tissue concentrations in fish and shellfish performed on behalf of EPA and the Puget Sound Estuary Program (PTI, 1991) and the DNR (SAIC, 1991) have not shown any differences in Bellingham Bay fish and shellfish muscle tissue and that collected from background reference sites. These studies demonstrate the lack of any significant benthic toxicity or bioaccumulation effects associated with these compounds. Whole-sediment bioassay testing as described in Section 5.2, coupled with the existing Bellingham tissue data were determined by Ecology to be sufficient for evaluation of dioxin/furan effects during the RI investigations.

5.1.2 ASB

The ASB sludges include wastewater solids produced during secondary treatment of wastewater from the GP pulp, tissue, chlor-alkali, and chemical plant operations between 1979 and the completion of the RI/FS investigations. Wastewater loadings to the ASB have been substantially reduced by closure of the pulp and chemical plants, and closure of the Chlor-Alkali Plant. Wastewaters currently managed by the ASB include stormwater, cooling water from the Encogen facility, and low-solids wastewaters from the tissue plant operations.

The ASB also includes subsurface sediment contamination associated with historic releases from the Chlor-Alkali Plant. This contamination is present in sediments beneath the ASB berm.

Key Constituents of Concern

Based on relative concentration and frequency of detection, the main contaminants present in the ASB sludges include the following:

- **4-Methylphenol:** The ASB sludges contained very high concentrations of 4-methylphenol. These concentrations ranged from 11 to over 250 times the SQS value. The abundance of this compound is associated with the accumulation of pulp solids and other woody materials in the ASB in the presence of anaerobic conditions. The ASB design maintained both aerobic and anaerobic conditions for optimization of wastewater treatment.

- **Mercury:** Most ASB sludge samples contained elevated concentrations of mercury from discharges of Chlor-Alkali Plant wastewaters and stormwaters. With the closure of the Chlor-Alkali Plant and pulp mill, the main source of mercury to the ASB has been terminated.

- **Phenol:** The compound phenol was present in most ASB sludge samples at concentrations above the SQS, though the relative concentrations and frequency of detection for phenol were lower than for 4-methylphenol. The phenol is associated with pulp mill and other effluents managed in the ASB.

- **Zinc and Cadmium:** Elevated concentrations of zinc and cadmium were detected in most of the ASB sludge samples. These compounds were most likely associated with operations of the chemical byproducts plant at the GP mill site. The chemical plant has been closed, terminating the main sources of these contaminants to the ASB.

Other Constituents

Several additional compounds were detected sporadically in the ASB sludges at concentrations in excess of the SQS. These compounds included bis(2-ethylhexyl)phthalate and butyl-benzyl-phthalate (each detected above their respective SQS values in two ASB sludge samples) and naphthalene which was detected above the SQS in one sample.

Chlorinated dibenzodioxins and dibenzofurans were also present in the ASB sludges at low but significant concentrations. These compounds do not have numeric SQS or MCUL values under SMS regulations. Their effects are measured directly using bioassays and measurements for bioaccumulation. These compounds are produced during the production of chlorine-bleached pulp and paper products. The compounds readily adsorb to high-organic particulates such as the pulp solids present in the ASB sludges, resulting in retention of these constituents within the ASB sludges.

5.2 Surface Sediment Quality

Sediment quality at the Whatcom Waterway Site was directly measured during sampling events in 1996 and 1998, and later in follow-up sampling performed in 2002. Sampling has demonstrated a reduction in both surface sediment chemical concentrations, including observed areas of surface sediment toxicity as measured by bioassay testing. Results for initial surface sediment quality from the first two sampling events (1996 and 1998) is presented in Section 5.2.1. Section 5.2.2 presents the updated sediment quality data collected in 2002, and discusses observed changes in sediment quality between these sampling events.

ASB sludges have been analyzed using sediment coring which composites surface and subsurface sediments together. For that reason, ASB sludges are not discussed in this section. ASB sludge sampling data, including data for the quality of the ASB berm materials are presented in Section 5.3.

5.2.1 Surface Sediment Quality in 1996-1998

During the 1996 and 1998 investigations, chemical testing was performed at 82 surface sediment sampling locations. Sediment samples from 40 site locations were then submitted for confirmatory biological testing to verify or refute sediment toxicity predicted on the basis of sediment chemical concentrations or the presence of wood material (Anchor and Hart Crowser, 2000). As set forth in the Whatcom Waterway RI/FS Project Plans, all surface samples that contained mercury concentrations above 0.59 mg/Kg (dry weight) or other chemicals that exceeded SMS screening criteria were submitted for confirmatory biological testing. In addition, confirmatory biological testing was also performed on those surface sediment samples collected from the Site contained elevated quantities of wood debris.

Sixty percent of the sediment samples submitted for biological testing (collected from 24 locations) were determined to be non-toxic (i.e., did not exceed SMS minor biological effects criteria). The remaining 40 percent of the locations exceeded SQS biological effects criteria, though only 15 percent (six locations) exceeded MCUL criteria based on more than minor biological effects. Apparent sediment toxicity correlations with specific contaminants are discussed in Section 5.2.3 below.

Figure 5-1 summarizes the surface sediment data from the 1996 and 1998 investigations, including the extent of surface mercury impacts. The results of confirmatory bioassays are shown in Figure 5-3. The following presents a summary of these distributions by analyte.

- **Mercury:** Mercury exceeded the MCUL criteria of 0.59 mg/kg in 39 of 82 surface samples. Concentrations of mercury were highest in the GP Log Pond. In general, mercury concentrations in surface sediments were significantly less than concentrations detected at depth, reflecting the implementation of source controls by GP beginning in the early 1970s, and associated natural recovery of sediments in response to these source reductions.

- **Phenolic Compounds**: In general, concentrations of phenolic compounds appeared to be correlated with accumulations of wood or organic debris, historic pulp mill wastes, and to some extent storm drains. Phenol can be derived from the natural degradation of plant matter. In addition, these compounds are fairly ubiquitous in storm drains near the site, based on data collected during Ecology's Drainage Basin Tracing Study (Cubbage, 1994).

Concentrations of phenolic compounds concentrations generally increased with depth indicating both a historical source as well as the tendency of these compounds to biodegrade readily when present in surface sediments.

5.2.2 Current Surface Sediment Quality

Figure 5-2 shows the surface sediment sampling data for mercury collected during the 2002 sampling event. Concentrations of site contaminants in surface sediments throughout the site were significantly lower during the 2002 sampling event, compared to previous 1996-1998 RI/FS samples.

As shown in Table 5-1, significant reductions in mercury concentrations were noted in 84 percent (all but three) of the samples which were co-located with previous sampling stations. The average concentration reduction observed in the co-located samples was 31 percent. The reduction in concentrations between the two sets of RI/FS sampling events is slightly greater than earlier natural recovery modeling predictions (Anchor and Hart Crowser, 2000). The reductions confirm other lines of evidence documenting the performance of natural recovery throughout portions of the site. These lines of evidence are discussed further in Section 6.0.

Only a single surface sampling station exceeded the mercury BSL during the 2002 sampling event. That station was located at Station SS-32 in the relatively high energy environment offshore of the ASB. The sediments in this area showed a lower fines content which are consistent with higher levels of wave energy. The higher wave energies in this area likely reduce rates of natural recovery and sedimentation that are present in other areas of the site. One sample station that previously exceeded the BSL in 1998 (HC-SC-79) was not resampled as part of the 2002 sampling effort. That station is carried forward in the RI/FS assuming that it continues to exceed the BSL.

Confirmatory biological testing of selected 2002 stations was performed to further evaluate compliance with SMS criteria (Figure 5-4). Of the 16 confirmatory bioassays conducted within the Whatcom Waterway Site, only one location, Station SS-30, did not meet SQS biological criteria during the 2002 sampling event. That station exhibited the presence of wood wastes and the presence of 2,4-dimethylphenol. Previous testing in 1996 and 1998 had exhibited the presence of wood waste, phenolic compounds, and bioassay toxicity at this same location.

Figure 5-3 and 5-4 also incorporate the results of chemical and bioassay testing performed at the Colony Wharf site on behalf of the Department of Ecology in 2004. The data report for that sampling event is attached as Appendix F. Contamination in that area is localized and will be remediated as part of coordinated cleanup of the Whatcom Waterway and Central Waterfront sites.

Surface sediments within the I&J Waterway Sediments Site are being managed separately from the Whatcom Waterway Site. Additional surface and subsurface testing is ongoing in this area as part of the I&J Waterway RI/FS.

Figure 5-5 summarizes the results of recent sampling of the Log Pond area. These data are from the Year-5 Monitoring Report (Appendix I). As discussed in that appendix, cap performance has been within design targets for most parameters. All surface sampling stations called for in the Operations Maintenance and Monitoring Plan (OMMP) passed the chemical or biological testing performance criteria, with one exception. Some sediment erosion has been noted around the cap edges along the Central Log Pond shoreline, and in the southwest corner of the Log Pond. Recontamination of a small portion of the cap surface was noted in the southwest corner of the Log Pond. Effects in this area were caused by wave-induced resuspension of impacted sediments from an area south of the cap limits, and migration of those sediments onto the cap surface. The affected area was delineated as part of the Year-5 monitoring event, and corrective actions are proposed as part of the remedial alternatives presented in the Feasibility Study. For a full discussion of the Year-5 monitoring event, refer to Appendix I of this RI report.

5.2.3 Review of Bioassay Test Data

Bioassay testing data from the 1996, 1998, and 2002 sampling events are summarized in Figures 5-6 through 5-9, and in Table 5-2. The data analysis is performed using the apparent effects threshold (AET) method on which the Sediment Management Standards SQS and MCUL criteria were initially developed (PSDDA, 1996). The method plots bioassay exceedances as a function of contaminant concentration. The AET is identified as the concentration above which toxic effects are consistently observed (after addressing “outlier” data points and other data issues).

The bioassay correlations shown in figures 5-6 through 5-9 incorporate all three bioassay methods (amphipod, larval, polychaete), plotting the toxicity result based on the overall SMS interpretive result. Using this method, a sample that passes two bioassays, but fails the third bioassay is plotted as a failure on the chart. This method is shown conservatively, given the relatively small number of data points. If individual organism test results are plotted, the conclusions about bioassay correlations are similar to those discussed below, with the exception of the amphipod test. The amphipod tests generated the fewest number of test failures, indicating that these organisms are generally less sensitive to the site contaminants in comparison to the larval and polychaete test organisms.

The bioassay correlations for 4-methylphenol (Figure 5-6) showed the strongest correlation between contaminant concentration and toxicity. At the highest concentrations measured, all bioassays failed SQS or MCUL/CSL performance standards. While the data are not likely sufficient for development of a site-specific AET, the results of testing suggest that the effects thresholds for 4-methylphenol are intermediate between the standard SMS SQS/CSL concentrations (0.67 mg/kg) and approximately 3.9 mg/kg.

The bioassay correlations were also fairly strong for phenol (Figure 5-7). Most samples containing phenol concentrations above the numeric SQS exhibited toxicity during conformational bioassays. There was one exception to this pattern at the highest phenol concentration measured. However, this sample would be treated as an "outlier" in the AET development process. The results suggest that site-specific phenol toxicity may be similar to the numeric SQS.

A poor correlation was observed between toxicity and 2,4-dimethylphenol concentrations (Figure 5-8). Passing bioassay results were observed for the majority of the samples that exceeded the numeric SQS and MCUL. The results suggest that the numeric SQS and MCUL overestimate the toxicity of this compound at the Whatcom Waterway Site. The site-specific data suggest that the toxicity threshold for this compound is above 0.19 mg/kg.

Bioassay correlations for mercury (Figure 5-9) are also poor. Site-specific bioassay testing confirmed that no toxic effects were observed at concentrations below the numeric SQS, except where elevated phenol or 4-methylphenol was present. However, the majority of samples tested between the SQS (0.41 mg/kg) and 2.9 mg/kg also exhibited no toxicity. Sporadic toxic results were observed in this range primarily in samples containing elevated phenolic compound. The results suggest that mercury concentrations are not toxic to benthic organisms at concentrations below the SQS or CSL, and that a site-specific AET, if developed, would likely be greater than 2.9 mg/kg. Sporadic toxicity observed between the numeric CSL and 2.9 mg/kg may be associated with synergies between multiple chemicals, or between chemical toxicity and conventional parameters.

The bioassay correlations discussed above are provided for discussion purposes only, to assist in the understanding of site conditions. The correlations were not used to develop site-specific numeric cleanup levels. As described further in the Feasibility Study, the cleanup levels for the site will continue to be based on a combination of SMS numeric standards, and conformational bioassay testing for samples with elevated chemical constituents. The continued use of whole-sediment bioassays in the monitoring process for samples containing elevated mercury or other contaminants ensures that any synergistic effects of multiple contaminants can be detected. The use of whole sediment bioassays also ensures that should toxicity be induced by an indirect mechanism (e.g., toxicity through methylmercury production rather than toxicity from inorganic mercury) this effect would be documented. The absence of toxicity in whole sediment bioassays provides a robust demonstration that the benthic organisms are being protected.

5.3 Subsurface Sediment Quality

Surface conditions in sediments at the Whatcom Waterway Site are generally compliant with sediment screening levels as measured using chemical and biological testing. The extent of natural recovery has been significant, resulting in attenuation of contaminant levels in the sediment bioactive zone and in immediately underlying sediments.

The purpose of the SMS is to reduce and ultimately to eliminate adverse effects on biological resources and significant health threats to humans from surface sediment contamination. Surface sediments are defined by the sediment bioactive zone, which was determined to be 12 centimeters (cm) for the Whatcom Waterway Site. However, if subsurface sediment has the potential to become surface sediment, through natural processes or through anthropogenic influences, it also must be addressed. Some of the factors affecting sediment stability include wave induced erosion, bioturbation, propeller wash, and anchor drag. These factors are discussed in Section 6 of this report. Area land use and navigation patterns and issues that have potential bearing on subsurface sediment exposure due to navigation dredging and/or land use actions are described in Section 3.3.

The RI/FS investigations included extensive testing of subsurface sediments. These subsurface data were developed to assist in the evaluation of long-term sediment stability, and also to support site remedial alternatives evaluations in the Feasibility Study.

Figures 5-10 through 5-13 and Table 5-3 summarize the subsurface data collected at the site during the RI/FS process. These data are discussed below for the areas outside the ASB (Section 5.3.1) and for the ASB (Section 5.3.2). Detailed data summaries and backup data are provided for each site area as part of the appendices to this report. Selected subsurface mercury concentrations are also shown on the geologic cross sections contained in Section 3 of this report (Figures 3-6 through 3-9).

5.3.1 Areas Outside the ASB

Figures 5-10 through 5-13 summarize average sediment quality within the shallow subsurface sediments throughout the site. The figures specifically show the average sediment quality at depths 0.4 feet to 4 feet below the sediment mud-line. Backup calculations are summarized in Appendix G. Note that the Log Pond area is shown prior to completion of sediment capping, to provide the reader with a better overall sense of subsurface contaminant distribution throughout the site prior to initiation of remedial efforts.

The 0.4 to 4 foot depth was selected because it represents the maximum depth of subsurface sediment that has a significant potential to be disturbed by natural or anthropogenic activities, in the absence of navigation dredging activities or anthropogenic shoreline changes. Such disturbance events are sporadic and are unlikely to result in complete mixing with the bioactive zone. Therefore, the information in Figures 5-10 through 5-13 provide a gross summary of shallow subsurface conditions, and are not direct measurements of potential risks to human health or ecological receptors.

Figure 5-10 summarizes subsurface sediment mercury concentrations. Mercury concentrations are highest in the remediated Log Pond area, which is where the historic discharge of mercury-containing wastewater was located during the 1960s and 1970s. Concentrations of mercury in the Waterway sediments decrease rapidly with distance from the Log Pond source area. Figure 5-11 illustrates the relationship between average subsurface mercury concentration and distance from the Log Pond.

Concentrations of 4-methylphenol are shown in Figure 5-12. This compound is present at elevated concentrations in areas near historic pulp mill wastewater discharges, including the head of the Whatcom Waterway and the ASB. Concentrations within the Whatcom Waterway are relatively low, reflecting the success of previous remedial efforts implemented in the 1970s, and the results of wastewater pollution controls implemented under the NPDES program. However, concentrations of 4-methylphenol remain very high in the ASB sludges, as described in Section 5.3.2 below.

Figure 5-13 presents an integrated view of all subsurface sediment contaminants in the 0.4 to 4 foot interval. The relative sediment composition is described using the cumulative enrichment ratio approach. The enrichment ratio for an individual compound is calculated by dividing the measured concentration by the SQS value for that compound. A compound present at the SQS has an enrichment ratio of one times, and a compound present at a concentration 10 times the SQS has an enrichment ratio of 10 times. Chemicals present below the SQS are assigned a value of zero, because the concentrations are below the no effects level for that compound. The enrichment ratios of individual compounds can then be compared on a risk-normalized basis to assess relative contributions of different contaminants to the overall impacts in a sample. The individual enrichment ratios can also be summed to produce an overall estimate of sample contamination, taking into account the additive effects of different compounds in the sediment sample. This cumulative enrichment ratio is plotted in Figure 5-13 using depth-weighted sediment concentrations.

By far, the highest average subsurface concentrations were noted in the ASB sludges. These materials are described in detail in Section 5.3.2 below. These materials contained elevated mercury, phenolic compounds, zinc, cadmium, and other contaminants.

In the outlying areas of the site, subsurface sediment concentrations were very low. These areas included the Outer portions of the Whatcom Waterway, areas offshore of the ASB, and in the I&J Waterway areas. As described in Section 7, subsurface testing of sediments in the Outer Whatcom Waterway has indicated that these sediments are likely suitable for beneficial reuse or PSDDA disposal.

Average sediment concentrations in the Whatcom Waterway are relatively low, with cumulative enrichment ratios averaging 10 times lower than those of the ASB sludges.

5.3.2 ASB Sludges, Berm Sands and Underlying Sands

Comprehensive sampling of the ASB sludges was completed in 2003, under an amendment to the RI Work Plan. That sampling event included core sampling of sludges and underlying sandy native sediments. This testing also included some testing of geotechnical properties of these materials. Additional testing was completed in 2004 and Amendment 5 to the RI Work Plan. That testing included physical and chemical testing of the ASB berm materials. Dewatering tests of the ASB sludges also performed as part of that sampling event are described separately in Section 7 of this report.

Appendix C contains the field information and detailed data summaries from the 2003 sampling event. Appendix D contains the detailed field information and data summaries from the 2004 sampling event.

ASB Sludge Composition

The ASB sludges consist of a soft, wet, high-organic sludge matrix, consistent with wastewater treatment biosolids mixed with settled pulp solids. The elevation of the base of the sludge layer was evaluated directly by probing to define the contact between the sludge materials and the underlying native sands at the base of the 1978 dredge prism. At that time the ASB basin had been dredged to a neat-line elevation of 12 feet below MLLW. Consistent with this target dredge elevation and associated overdredge allowances (typically 2-3 feet for historical production dredging), the base of the sludge bed was measured between 13 and 16 feet throughout the majority of the basin. Assuming an average sludge bed base elevation of 15 feet below MLLW, the volume of ASB sludges was estimated at approximately 378,000 cubic yards.

Table 5-3 summarizes the average composition of the ASB sludges. The average composition is compared to the results for subsurface waterway sediments in remaining remediation areas (excluding the I&J Waterway and the remediated Log Pond area), the materials underlying the ASB sludges, and the ASB berm sands. Results presented in Table 5-3 include the average measured concentration, as well as the average enrichment ratios for each compound.

The ASB sludges are characterized by a low solids content and a high organic carbon content. The average sludge dry weight measurements were 17 percent. Some gradations in solids content were observed, with deeper sludges generally higher in solids content than shallow layers, suggesting some consolidation of the sludge bed has occurred. Some gradations were also observed in the different ASB areas, consistent with differential settling of wastewater solid fractions. The TOC content of the ASB sludges averaged 33 percent, over six times greater than the average Waterway sediment composition. As with the solids content, some variation in the TOC content was observed.

The key constituents in the ASB sludges included mercury, 4-methylphenol, phenol, zinc, and cadmium. The mercury concentrations in the ASB sludges were greater than the average concentration in the Waterway sediments. The enrichment ratios for mercury averaged 14 times in the ASB sludges, compared to less than nine times for the Waterway sediments. Mercury concentrations ranged to a maximum value of 20.2 mg/kg in the ASB sludges. The 4-methylphenol concentrations averaged over 54,000 µg/kg, with an average enrichment ratio of over 80 times. The abundance of 4-methylphenol is consistent with the use of the basin for secondary treatment of wastewaters containing pulp solids, and the presence of anaerobic zones within the basin as part of dual aerobic/anaerobic treatment process. Phenol concentrations were lower, with an average enrichment ratio of approximately two times. The related compound 2,4-dimethyl phenol was present with an average enrichment ratio between three times and four times.

Other than mercury and phenolic compounds, the key constituents present in the ASB sludges included zinc and cadmium. These compounds had average enrichment ratios of 2.5 times and 4.5 times, respectively.

Other constituents present in the ASB sludges included two phthalate compounds and selected polyaromatic hydrocarbons (PAH) compounds. The phthalate compounds included bis(2-ethylhexyl)phthalate and butyl-benzyl-phthalate. These compounds were each present above the SQS in only two of 10 sludge samples. The PAH compounds detected above the SQS included acenaphthene, naphthalene and phenanthrene. Each compound was present above the SQS in only one of 10 sludge samples.

The 2003 sampling included testing for dioxin and furan compounds. Testing was performed on a single ASB sludge composite sample. The composite sample results are presented in Appendix C. The results of these analyses are expressed as the toxicity equivalent concentration (TEC) of 2,3,7,8-tetrachlorodibenzodioxin (TCDD) the compound with the greatest biological activity. The TEC concentration for the composite sludge sample was 0.230 µg/kg (230 ng/kg or parts per trillion). As described in Section 4.2, there currently is no SQS for dioxin compounds. For comparison, the measured concentration is greater than the PSDDA screening level for dioxins (15 ng/kg as TEC) and is intermediate between the MTCA upland direct-contact cleanup levels for dioxins (6.67 ng/kg for unrestricted land use, and 875 ng/kg for industrial land uses).

Composition of ASB Berm Sands

Table 5-3 also summarizes the average composition of the ASB berm sands and the sandy native sediments beneath the ASB sludges. As described in Section 3.1, the ASB berm is a composite structure constructed of stone, sand and other materials. The sand layer includes over 200,000 tons of imported quarry sands placed within the inner portions of the ASB berm structure in 1978 and 1979. Some contaminated sediments are remain beneath portions of the berm structure, but the dredging of the ASB basin in 1978 removed most contaminated materials from this area prior to ASB construction (Figures 3-6 and 3-8).

As shown in Table 5-3, the average concentrations in the ASB berm sands were all well below screening levels. Average berm sand mercury concentrations were well below the SQS of 0.41 mg/kg. The average concentrations of 4-methylphenol were also well below the SQS. Using a TOC-normalized basis, one compound (bis-2-ethylhexylphthalate or BEP) was detected slightly above the SQS in one of eight samples. However, this is mainly a result of the low TOC content of the berm sands. The measured dry weight concentration of BEP was below the corresponding lowest apparent effects threshold (LAET) which is used for evaluation of effects thresholds for low TOC sediments. Testing results confirm that the ASB berm sands have not been significantly affected by wastewater or sludge contaminants from the ASB operation.

Dioxin concentrations were tested in two berm composite samples. Results of testing are summarized in Appendix D. The measured concentrations (reported on a TEC concentration basis) are well below all applicable reference values (PSDDA screening level, MTCA upland soil Method B level for unrestricted land use).

Composition of Sandy Sediments Underlying ASB Sludges

The average composition of the sandy native sediments underlying the ASB sludges is shown in Table 5-3. As shown in Table 5-3, the average concentrations of the ASB sludge and Waterway sediment contaminants were below the screening levels. Results indicate that the contaminants of the ASB sludges have not significantly impacted the underlying sandy sediments, and that the ASB sludges transition rapidly to clean underlying sands.

The average mercury concentration in the underlying sand unit is approximately 0.1 mg/kg, well below the SQS of 0.41 mg/kg. The average concentration of 4-methylphenol is 177 µg/kg, well below the SQS of 670 µg/kg.

Some contaminated sediments are expected to be present at the former mud-line elevations beneath the outer portions of the ASB berm. These areas were not historically dredged at the time of ASB construction. If berm materials are removed as part of future remediation or redevelopment activities, these sediments will be tested to determine appropriate management options. These testing and material management costs are incorporated into the Feasibility Study.

Table 5-1. Observed Reduction in Mercury Concentrations Between RI/FS Sampling Events

Location ID	Sample ID	Sample Date	Mercury Concentration (mg/kg)	Reduction in Mercury Concentration (mg/kg)	Reduction in Mercury Concentration (%)	Compliance with Biological SQS and Site BSL*
Depositional Areas						
HC-SS-03	HC-SS-03	9/6/1996	0.32			
AN-SS-03	AN-SS-03	6/7/2002	0.20	0.12	38%	Yes
HC-SS-08	HC-SS-08	9/6/1996	0.53			
AN-SS-08	AN-SS-08	6/7/2002	0.42	0.11	21%	Yes
HC-SS-13	HC-SS-13	9/4/1996	1.00			
AN-SS-13	AN-SS-13	6/6/2002	0.99	0.01	1%	Yes
HC-SS-22	HC-SS-22	9/6/1996	0.93			
AN-SS-22	AN-SS-22	6/6/2002	0.30	0.63	68%	Yes
HC-SS-23	HC-SS-23	9/6/1996	2.00			
AN-SS-23	AN-SS-23	6/6/2002	1.09	0.91	46%	Yes
HC-SS-24	HC-SS-24	9/6/1996	1.90			
AN-SS-24	AN-SS-24	6/6/2002	1.10	0.80	42%	Yes
HC-SS-25	HC-SS-25	9/6/1996	1.00			
AN-SS-25	AN-SS-25	6/6/2002	0.80	0.20	20%	Yes
HC-SS-26	HC-SS-26	9/5/1996	0.38			
AN-SS-26	AN-SS-26	6/6/2002	0.26	0.12	32%	Yes
HC-SS-29	HC-SS-29	9/6/1996	0.70			
AN-SS-29	AN-SS-29	6/7/2002	0.50	0.20	29%	Yes
HC-SS-30	HC-SS-30	9/6/1996	0.49			
AN-SS-30	AN-SS-30	6/7/2002	0.40	0.09	18%	No/Yes**
HC-SS-31	HC-SS-31	9/9/1996	0.37			
AN-SS-31	AN-SS-31	6/7/2002	0.40	-0.03	-8%	Yes
HC-SS-33	HC-SS-33	9/9/1996	0.89			
AN-SS-33	AN-SS-33	6/7/2002	1.02	-0.13	-15%	Yes
HC-SS-34	HC-SS-34	9/9/1996	1.50			
AN-SS-34	AN-SS-34	6/7/2002	0.56	0.94	63%	Yes
HC-SS-35	HC-SS-35	9/3/1996	0.73			
AN-SS-35	AN-SS-35	6/7/2002	0.50	0.23	32%	Yes
HC-SC-80	HC-SC-80	9/9/1996	0.56			
AN-SS-80	AN-SS-80	6/7/2002	0.40	0.16	29%	Yes
HC-SC-81	HC-SC-81	9/9/1996	0.42			
AN-SS-81	AN-SS-81	6/7/2002	0.27	0.15	36%	Yes
AN-SS-303	AN-SS-303	10/26/98	2.90			
AN-SS-303	AN-SS-303	6/7/2002	0.82	2.08	72%	Yes
AN-SS-305	AN-SS-305	10/26/98	1.50			
AN-SS-305	AN-SS-305	6/7/2002	1.00	0.50	33%	Yes
				Average	31%	
				Median	32%	
Nearshore, High-Energy Areas						
HC-SS-32	HC-SS-32	9/5/1996	0.73			
AN-SS-32	AN-SS-32	6/6/2002	2.55	NA	NA	No

Notes:

*: Based on most recent sampling event.

**: Sample passed chemical SQS for mercury, but failed the amphipod bioassay.

Table 5-2 Concise Summary Site Bioassay Data

Bioassay Sample	Concentrations of Key Constituents (mg/kg)				Other Contaminants Detected Above SQS	Amphipod	Larval Bivalve	Juvenile Polychaete	Overall SMS Interpretive Result
	Mercury (SQS = 0.41)	**Phenol** (SQS = 0.42)	**4-Methylphenol** (SQS = 0.67)	**2,4-Dimethylphenol** (SQS = 0.029)		*Eohaustorius estuaris*	*Mytilus sp. or Dendraster sp.*	*Neanthes sp.*	
1996 Bioassays (see Appendix B)									
HC-SS-03	0.32	**0.9** E	**1.6** E	0.023 UE	none	Pass	Pass	**SQS**	**SQS**
HC-SS-06	0.39	**2.2** E	**1.9** E	0.024 UE	none	Pass	Pass	Pass	Pass
HC-SS-08	**0.53**	**1** E	**0.87** E	0.0023 E	none	Pass	**MCUL**	Pass	**MCUL**
HC-SS-13	**1**	na	na	na	none	Pass	Pass	**SQS**	**SQS**
HC-SS-14	**0.77**	na	na	na	none	Pass	Pass	Pass	Pass
HC-SS-15	**0.67**	na	na	na	none	Pass	Pass	Pass	Pass
HC-SS-17	**0.58**	na	na	na	none	Pass	Pass	Pass	Pass
HC-SS-19	**0.62**	na	na	na	none	Pass	Pass	Pass	Pass
HC-SS-21	**1.2**	na	na	na	none	Pass	Pass	Pass	Pass
HC-SS-22	**0.93**	na	na	na	none	Pass	Pass	**SQS**	**SQS**
HC-SS-23	**2**	na	na	na	none	Pass	Pass	**SQS**	**SQS**
HC-SS-24	**1.9**	na	na	na	none	Pass	Pass	Pass	Pass
HC-SS-25	**1**	na	na	na	none	Pass	**MCUL**	Pass	**MCUL**
HC-SS-26	0.38	na	na	na	none	Pass	**SQS**	Pass	**SQS**
HC-SS-29	**0.7**	**1** E	0.41 E	0.0063 E	none	Pass	**SQS**	Pass	**SQS**
HC-SS-30	**0.49**	**1.3** E	**0.68** E	0.0021 E	none	Pass	**MCUL**	Pass	**MCUL**
HC-SS-31	0.37	na	na	na	none	Pass	**MCUL**	Pass	**MCUL**
HC-SS-32	**0.73**	na	na	na	none	Pass	**SQS**	Pass	**SQS**
HC-SS-33	**0.89**	0.27	0.2	0.0023 E	none	Pass	**SQS**	Pass	**SQS**
HC-SS-34	**1.5**	0.23	**0.87**	0.0042 E	Hexachlorobenzene	Pass	**MCUL**	Pass	**MCUL**
HC-SS-35	**0.73**	**1.5**	0.34	0.023 U	none	Pass	**MCUL**	Pass	**MCUL**
HC-SS-41	0.13 U	na	na	na	none	Pass	Pass	Pass	Pass
1998 Bioassays (see Appendix B)						Pass	Pass	Pass	Pass
AN-SS-36	**0.61**	0.036	0.3	0.019 U	none	Pass	Pass	Pass	Pass
AN-SS-37	**0.5**	0.019 U	0.2	0.019 U	none	Pass	Pass	Pass	Pass
AN-SC-70	**0.85**	0.019 U	0.24	0.019 U	none	Pass	Pass	Pass	Pass
AN-SC-71	**1.2**	0.02 U	0.29	0.02 U	none	Pass	Pass	Pass	Pass
AN-SC-72	**0.9**	0.02 U	0.24	0.02 U	none	Pass	Pass	Pass	Pass
AN-SC-73	**0.81**	0.02 U	0.17	0.02 U	none	Pass	Pass	Pass	Pass
AN-SC-77	**1.2**	0.02 U	0.14	0.02 U	none	Pass	Pass	Pass	Pass
AN-SC-78	**1**	0.02 U	0.16	0.02 U	none	Pass	Pass	Pass	Pass
AN-SC-80	**0.71**	0.039 U	0.14	0.039 U	none	Pass	**SQS**	Pass	**SQS**
AN-SC-81	**0.62**	0.02 U	0.089	0.02 U	none	Pass	**SQS**	Pass	**SQS**
AN-SC-82	**0.52**	0.02 U	0.084	0.02 U	none	Pass	Pass	Pass	Pass
AN-SC-84	**0.45**	0.034	0.062	0.02 U	none	Pass	Pass	Pass	Pass
AN-SS-301	**1**	0.04 U	0.086	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-302	**0.45**	0.024 G	0.19	0.02 U	none	Pass	Pass	Pass	Pass
AN-SS-303	**2.9**	0.033 G	0.07	0.02 U	none	Pass	Pass	Pass	Pass
AN-SS-304	0.062	0.036 G	0.12	0.019 U	none	Pass	Pass	Pass	Pass
AN-SS-305	**1.5**	0.052 G	0.19	0.022 U	none	Pass	Pass	Pass	Pass
AN-SS-306	**0.74**	0.058 G	0.036	0.019 U	none	Pass	Pass	Pass	Pass

Table 5-2 Concise Summary Site Bioassay Data

Bioassay Sample	Concentrations of Key Constituents (mg/kg)				Other Contaminants Detected Above SQS	Amphipod	Larval Bivalve	Juvenile Polychaete	Overall SMS Interpretive Result
	Mercury (SQS = 0.41)	**Phenol** (SQS = 0.42)	**4-Methylphenol** (SQS = 0.67)	**2,4-Dimethylphenol** (SQS = 0.029)		*Eohaustorius estuaris*	*Mytilus sp. or Dendraster sp.*	*Neanthes sp.*	
1998 Subsurface Bioassays (see Appendix H)									
HC-VC-94-C1	**<u>1.3</u>**	0.034 B	0.13	0.014 E	none	Pass	Pass	Pass	Pass
HC-VC-94-C2	**<u>1.8</u>**	0.023 B	0.078	0.0084 E	none	Pass	Pass	Pass	Pass
HC-VC-95-C1	**<u>0.68</u>**	0.16 B	0.46	0.19 E	2-Methylphenol	Pass	Pass	Pass	Pass
HC-VC-95-C2	0.15	0.063 B	0.26	0.12 E	2-Methylphenol	Pass	Pass	Pass	Pass
HC-VC-96-C1	**<u>2.7</u>**	0.21 B	**<u>4.6</u>**	0.008 E	Hexachlorobenzene	Pass	**MCUL**	**MCUL**	**MCUL**
HC-VC-96-C2	**<u>4.3</u>**	0.23 B	**<u>12</u>**	0.046	Cadmium	Pass	**MCUL**	**MCUL**	**MCUL**
HC-VC-97-C1	**<u>1.8</u>**	0.19 B	**<u>3.9</u>**	0.0088 E	none	Pass	Pass	Pass	Pass
HC-VC-96-C2	**<u>2.5</u>**	0.29 B	**<u>7.6</u>**	0.019 E	none	**MCUL**	**MCUL**	**MCUL**	**MCUL**
2002 Bioassays (see Appendix A)									
AN-SS-03	0.2	0.1 U	0.29	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-08	**<u>0.42</u>**	0.099 U	0.07	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-13	**<u>0.99</u>**	0.1 U	0.045	**<u>0.046</u>**	none	Pass	Pass	Pass	Pass
AN-SS-22	0.3	0.1 U	0.069	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-23	**<u>1.09</u>**	0.1 U	0.036	**<u>0.053</u>**	none	Pass	Pass	Pass	Pass
AN-SS-25	**<u>0.8</u>**	0.099 U	0.055	**<u>0.075</u>**	none	Pass	Pass	Pass	Pass
AN-SS-26	0.26	0.098 U	0.022	0.039 U	none	Pass	Pass	Pass	Pass
AN-SS-29	**<u>0.5</u>**	0.13	0.11	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-30	0.4	0.099 U	0.093	**<u>0.05</u>**	none	**MCUL**	Pass	Pass	**MCUL**
AN-SS-31	0.4	0.1 U	0.048	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-32	**<u>2.55</u>**	0.099 U	0.046	0.039 U	none	Pass	Pass	Pass	Pass
AN-SS-33	**<u>1.02</u>**	0.099 U	0.083	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-34	**<u>0.56</u>**	0.1 U	0.092	**<u>0.087</u>**	none	Pass	Pass	Pass	Pass
AN-SS-35	**<u>0.5</u>**	0.12 U	0.14	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-80	0.4	0.1 U	0.13	0.04 U	none	Pass	Pass	Pass	Pass
AN-SS-81	0.27	0.099 U	0.31	**<u>0.042</u>**	none	Pass	Pass	Pass	Pass
AN-SS-305	**<u>0.82</u>**	0.099 U	0.086	0.039 U	none	Pass	Pass	Pass	Pass
AN-SS-306	**<u>1</u>**	0.1 U	0.077	**<u>0.077</u>**	none	Pass	Pass	Pass	Pass
Year-5 Log Pond Monitoring									
SC-76	**<u>0.58</u>**	0.059 U	0.059 U	0.059 U	none	Pass	Pass	Pass	Pass

Notes:

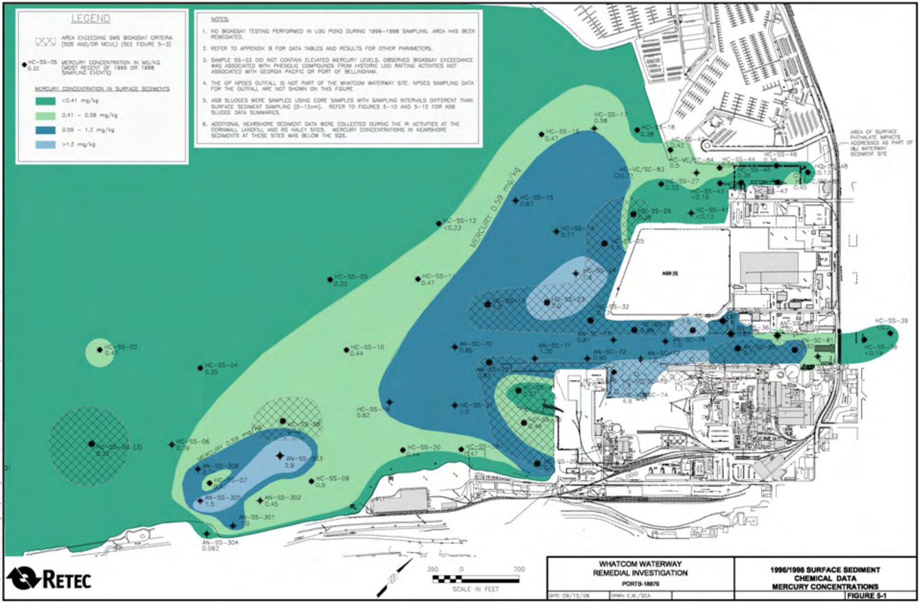
This table excludes bioassay testing performed for the I&J Waterway site and in the nearshore area adjacent to the Colony Wharf site. Bioassay failures in these areas are attributable to localized sources.
Bolded and underlined results indicate a detected contaminant concentration in excess of the numeric SQS.
na: Sample not analyzed for indicated parameter.

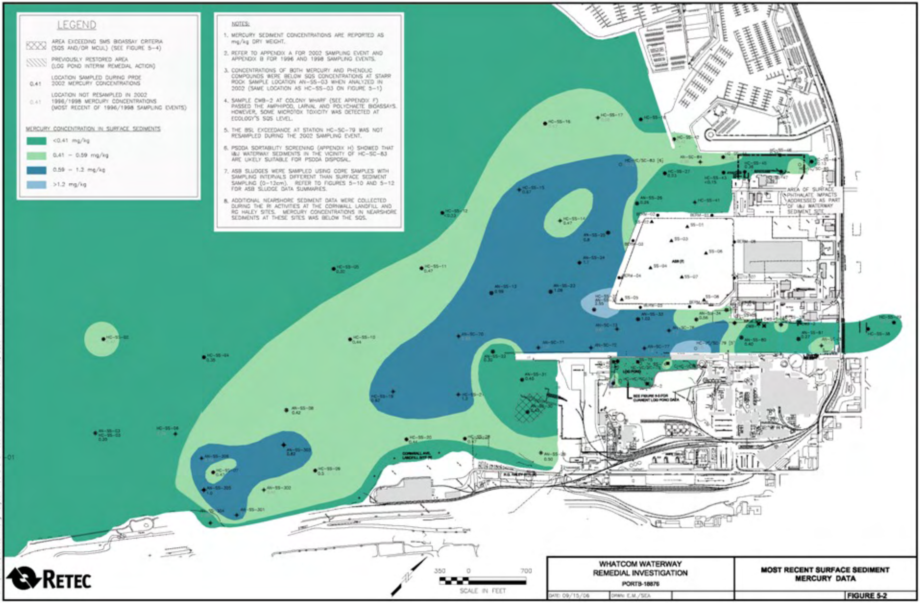
Table 5-3. Average Properties of Site Subsurface Sediments and ASB Materials

Parameter	Units	SQS	Remaining Waterway Site Sediments [1]		ASB Sludges		Native Sands Underlying ASB Sludges [2]		ASB Berm Sands	
			Avg Conc.	Enrichment Ratio	Avg Conc.	Enrichment Ratio	Avg Conc.	Enrichment Ratio	Avg Conc.	Enrichment Ratio
CUMULATIVE ENRICHMENT RATIO			--	**12**	--	**120**	--	**< 1**	--	**< 1**
Conventional Parameters										
Total Solids	%	--	48	--	17.4	--	82.9	--	96.0	--
Total Organic Carbon	%	--	4.3	--	33.2	--	0.51	--	0.15	--
Heavy Metals										
Mercury	mg/kg dwt	0.41	3.5	**8.6**	5.7	**14**	0.1	< 1	0.05	< 1
Cadmium	mg/kg dwt	5.1	1.7	< 1	12.6	**2.5**	0.4	< 1	0.2	< 1
Zinc	mg/kg dwt	410	161	< 1	1840	**4.5**	29.7	< 1	33.2	< 1
Phenolic Compounds										
4-Methylphenol	ug/kg dwt	670	1,995	**3.0**	54373	**81**	177	< 1	19 U	< 1
Phenol	ug/kg dwt	420	92	< 1	866	**2.1**	8.9	< 1	19 U	< 1
2-4-Dimethylphenol	ug/kg dwt	29	15	< 1	102	**3.5**	9.3	< 1	19 U	< 1
PAH Compounds										
Naphthalene	ppm TOC	99	12	< 1	28	< 1	13	< 1	15 U	< 1
Fluorene	ppm TOC	23	9.4	< 1	1.0	< 1	1.5 U	< 1	15 U	< 1
Acenaphthene	ppm TOC	16	7.4	< 1	1.4	< 1	1.2 U	< 1	15 U	< 1
Phenanthrene	ppm TOC	100	54	< 1	18	< 1	11.6	< 1	15 U	< 1
Fluoranthene	ppm TOC	160	81	< 1	17	< 1	11.8 U	< 1	15 U	< 1
Chrysene	ppm TOC	110	39	< 1	1.9	< 1	1.8	< 1	15 U	< 1
Pyrene	ppm TOC	1000	82	< 1	17	< 1	10.3	< 1	15 U	< 1
Benzo(a)anthracene	ppm TOC	110	27	< 1	1.0	< 1	1.4 U	< 1	15 U	< 1
Benzo(b&k)fluoranthenes	ppm TOC	230	34	< 1	6.5	< 1	3.4 U	< 1	30 U	< 1
Dibenz(a,h)anthracene	ppm TOC	12	4.4	< 1	0.70	< 1	1.3 U	< 1	15 U	< 1
Other Semivolatile Organics										
Bis(2-ethylhexyl)phthalate	ppm TOC	47	10	< 1	83	**1.8**	36	< 1	27.6	< 1
Butyl-benzyl-phthalate	ppm TOC	4.9	2.2	< 1	51	**10.4**	10.3 U	< 1	19 U	< 1
Hexachlorobenzene	ppm TOC	0.38	0.3	< 1	< 0.01	< 1	0.2	< 1	15 U	< 1
Dibenzofuran	ppm TOC	15	8.2	< 1	nt	nc	nt	nc	15 U	< 1

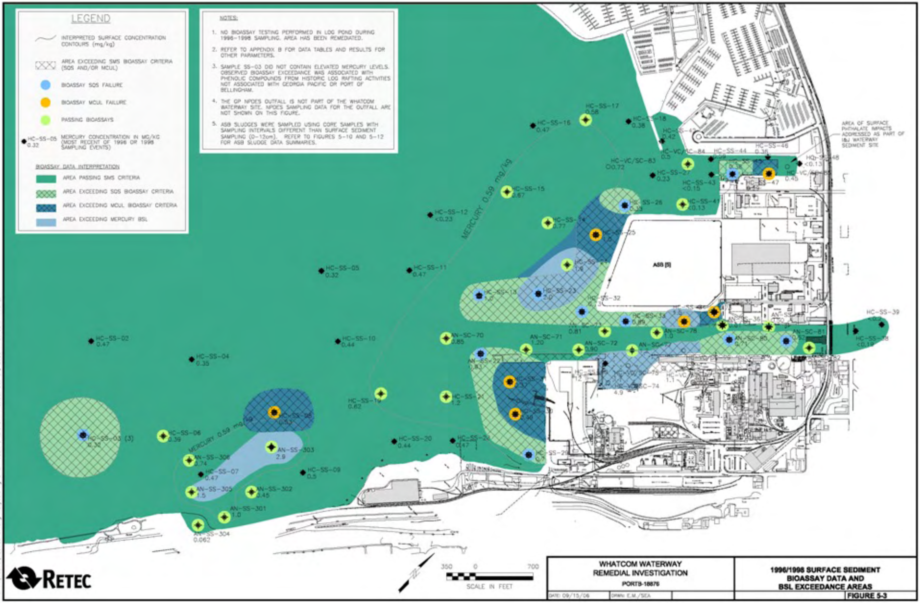
Notes:

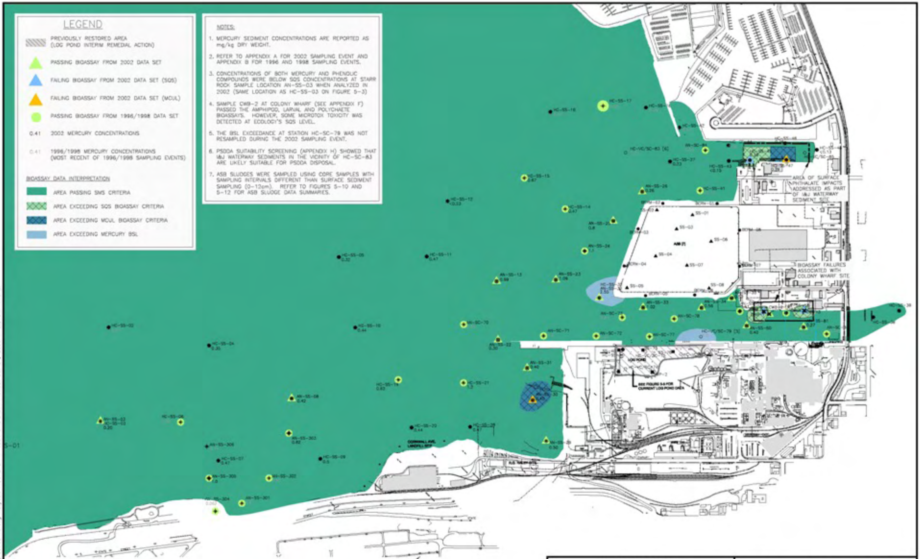
U: Compound not detected in any samples. Posted result is the average reporting limit of analyzed samples.
--: No applicable value
nc: Not calculated
nt: Not tested
Refer to Appendix G for detailed enrichment ratio calculations
1. Excludes previously remediated portions of the Log Pond.
2. Excludes ASB sludges and the sludge/sediment contact layer samples. Generally consists of sandy sediments below -16 ft MLLW elevation in ASB area.


LEGEND
AREA EXCEEDING SMS BIOASSAY CRITERIA (SQS AND/OR MCUL) (SEE FIGURE 5-3)
HC-SS-05 0.32 MERCURY CONCENTRATION IN MG/KG (MOST RECENT OF 1996 OR 1998 SAMPLING EVENTS)
MERCURY CONCENTRATION IN SURFACE SEDIMENTS
<0.41 mg/kg
0.41 - 0.59 mg/kg
0.59 - 1.2 mg/kg
>1.2 mg/kg
NOTES:
1. NO BIOASSAY TESTING PERFORMED IN LOG POND DURING 1996-1998 SAMPLING. AREA HAS BEEN REMEDIATED.
2. REFER TO APPENDIX B FOR DATA TABLES AND RESULTS FOR OTHER PARAMETERS.
3. SAMPLE SS-03 DID NOT CONTAIN ELEVATED MERCURY LEVELS. OBSERVED BIOASSAY EXCEEDANCE WAS ASSOCIATED WITH PHENOLIC COMPOUNDS FROM HISTORIC LOG RAFTING ACTIVITIES NOT ASSOCIATED WITH GEORGIA PACIFIC OR PORT OF BELLINGHAM.
4. THE GP NPDES OUTFALL IS NOT PART OF THE WHATCOM WATERWAY SITE. NPDES SAMPLING DATA FOR THE OUTFALL ARE NOT SHOWN ON THIS FIGURE
5. ASB SLUDGES WERE SAMPLED USING CORE SAMPLES WITH SAMPLING INTERVALS DIFFERENT THAN SURFACE SEDIMENT SAMPLING (0-12cm). REFER TO FIGURES 5-10 AND 5-12 FOR ASB SLUDGE DATA SUMMARIES.
6. ADDITIONAL NEARSHORE SEDIMENT DATA WERE COLLECTED DURING THE RI ACTIVITIES AT THE CORNWALL LANDFILL AND RG HALEY SITES. MERCURY CONCENTRATIONS IN NEARSHORE SEDIMENTS AT THESE SITES WAS BELOW THE SQS.
MERCURY 0.59 mg/kg
AREA OF SURFACE PHTHALATE IMPACTS ADDRESSED AS PART OF I&J WATERWAY SEDIMENT SITE
HC-SS-05 0.32
HC-SS-02 0.47
HC-SS-04 0.35
HC-SS-03 (3) 0.32
HC-SS-06 0.39
HC-SS-10 0.44
HC-SS-12 <0.23
HC-SS-15 0.67
HC-SS-14 0.77
HC-SS-09 0.5
HC-SS-17 0.58
HC-SS-18 0.38
HC-SS-39
HC-SS-78 <0.19
AN-SS-303 2.9
AN-SS-305 1.5
AN-SS-302 0.45
AN-SS-301 1.0
AN-SS-304 0.062
AN-SC-70 0.85
AN-SC-71 1.20
AN-SC-72 0.90
HC-SS-21 1.2
HC-SS-19 0.62
ASB
RETEC
350 0 700
SCALE IN FEET
WHATCOM WATERWAY
REMEDIAL INVESTIGATION
PORTB-18876
DATE: 09/15/06
DRWN: E.M./SEA
1996/1998 SURFACE SEDIMENT
CHEMICAL DATA
MERCURY CONCENTRATIONS
FIGURE 5-1



LEGEND
AREA EXCEEDING SMS BIOASSAY CRITERIA (SQS AND/OR MCUL) (SEE FIGURE 5-4)
PREVIOUSLY RESTORED AREA (LOG POND INTERIM REMEDIAL ACTION)
0.41 LOCATION SAMPLED DURING PRDE 2002 MERCURY CONCENTRATIONS
0.41 LOCATION NOT RESAMPLED IN 2002 1996/1998 MERCURY CONCENTRATIONS (MOST RECENT OF 1996/1998 SAMPLING EVENTS)
MERCURY CONCENTRATION IN SURFACE SEDIMENTS
<0.41 mg/kg
0.41 - 0.59 mg/kg
0.59 - 1.2 mg/kg
>1.2 mg/kg
NOTES:
1. MERCURY SEDIMENT CONCENTRATIONS ARE REPORTED AS mg/kg DRY WEIGHT.
2. REFER TO APPENDIX A FOR 2002 SAMPLING EVENT AND APPENDIX B FOR 1996 AND 1998 SAMPLING EVENTS.
3. CONCENTRATIONS OF BOTH MERCURY AND PHENOLIC COMPOUNDS WERE BELOW SQS CONCENTRATIONS AT STARR ROCK SAMPLE LOCATION AN-SS-03 WHEN ANALYZED IN 2002 (SAME LOCATION AS HC-SS-03 ON FIGURE 5-1)
4. SAMPLE CWB-2 AT COLONY WHARF (SEE APPENDIX F) PASSED THE AMPHIPOD, LARVAL AND POLYCHAETE BIOASSAYS. HOWEVER, SOME MICROTOX TOXICITY WAS DETECTED AT ECOLOGY'S SQS LEVEL.
5. THE BSL EXCEEDANCE AT STATION HC-SC-79 WAS NOT RESAMPLED DURING THE 2002 SAMPLING EVENT.
6. PSDDA SORTABILITY SCREENING (APPENDIX H) SHOWED THAT I&J WATERWAY SEDIMENTS IN THE VICINITY OF HC-SC-83 ARE LIKELY SUITABLE FOR PSDDA DISPOSAL.
7. ASB SLUDGES WERE SAMPLED USING CORE SAMPLES WITH SAMPLING INTERVALS DIFFERENT THAN SURFACE SEDIMENT SAMPLING (0-12cm). REFER TO FIGURES 5-10 AND 5-12 FOR ASB SLUDGE DATA SUMMARIES.
8. ADDITIONAL NEARSHORE SEDIMENT DATA WERE COLLECTED DURING THE RI ACTIVITIES AT THE CORNWALL LANDFILL AND RG HALEY SITES. MERCURY CONCENTRATIONS IN NEARSHORE SEDIMENTS AT THESE SITES WAS BELOW THE SQS.
AREA OF SURFACE PHTHALATE IMPACTS ADDRESSED AS PART OF I&J WATERWAY SEDIMENT SITE
SEE FIGURE 5-5 FOR CURRENT LOG POND DATA
RETEC
350 0 700
SCALE IN FEET
WHATCOM WATERWAY
REMEDIAL INVESTIGATION
PORTB-18876
DATE: 09/15/06
DRWN: E.M./SEA
MOST RECENT SURFACE SEDIMENT MERCURY DATA
FIGURE 5-2


LEGEND
INTERPRETED SURFACE CONCENTRATION CONTOURS (mg/kg)
AREA EXCEEDING SMS BIOASSAY CRITERIA (SQS AND/OR MCUL)
BIOASSAY SQS FAILURE
BIOASSAY MCUL FAILURE
PASSING BIOASSAYS
HC-SS-05 0.32 MERCURY CONCENTRATION IN MG/KG (MOST RECENT OF 1996 OR 1998 SAMPLING EVENTS)
BIOASSAY DATA INTERPRETATION
AREA PASSING SMS CRITERIA
AREA EXCEEDING SQS BIOASSAY CRITERIA
AREA EXCEEDING MCUL BIOASSAY CRITERIA
AREA EXCEEDING MERCURY BSL
NOTES:
1. NO BIOASSAY TESTING PERFORMED IN LOG POND DURING 1996-1998 SAMPLING. AREA HAS BEEN REMEDIATED.
2. REFER TO APPENDIX B FOR DATA TABLES AND RESULTS FOR OTHER PARAMETERS.
3. SAMPLE SS-03 DID NOT CONTAIN ELEVATED MERCURY LEVELS. OBSERVED BIOASSAY EXCEEDANCE WAS ASSOCIATED WITH PHENOLIC COMPOUNDS FROM HISTORIC LOG RAFTING ACTIVITIES NOT ASSOCIATED WITH GEORGIA PACIFIC OR PORT OF BELLINGHAM.
4. THE GP NPDES OUTFALL IS NOT PART OF THE WHATCOM WATERWAY SITE. NPDES SAMPLING DATA FOR THE OUTFALL ARE NOT SHOWN ON THIS FIGURE.
5. ASB SLUDGES WERE SAMPLED USING CORE SAMPLES WITH SAMPLING INTERVALS DIFFERENT THAN SURFACE SEDIMENT SAMPLING (0-12cm). REFER TO FIGURES 5-10 AND 5-12 FOR ASB SLUDGE DATA SUMMARIES.
MERCURY 0.59 mg/kg
AREA OF SURFACE PHTHALATE IMPACTS ADDRESSED AS PART OF I&J WATERWAY SEDIMENT SITE
ASB [5]
HC-SS-02 0.47
HC-SS-04 0.35
HC-SS-05 0.32
HC-SS-10 0.44
HC-SS-11 0.47
HC-SS-12 <0.23
HC-SS-15 0.67
HC-SS-16 0.47
HC-SS-17 0.58
HC-SS-20 0.44
HC-SS-06 0.39
HC-SS-07 0.47
HC-SS-09 0.5
AN-SS-301 1.0
AN-SS-302 0.45
AN-SS-303 2.9
AN-SS-304 0.062
AN-SS-305 1.5
AN-SC-70 0.85
AN-SC-71 1.20
AN-SC-72 0.90
HC-SS-39
350 0 700
SCALE IN FEET
RETEC
WHATCOM WATERWAY
REMEDIAL INVESTIGATION
PORTB-18876
DATE: 09/15/06
DRWN: E.M./SEA
1996/1998 SURFACE SEDIMENT
BIOASSAY DATA AND
BSL EXCEEDANCE AREAS
FIGURE 5-3



RETEC

WHATCOM WATERWAY
REMEDIAL INVESTIGATION
PORTB-18876

DATE: 09/15/06 DRWN: E.M./SEA

MOST RECENT SURFACE SEDIMENT BIOASSAY DATA AND BSL EXCEEDANCE AREAS

FIGURE 5-4